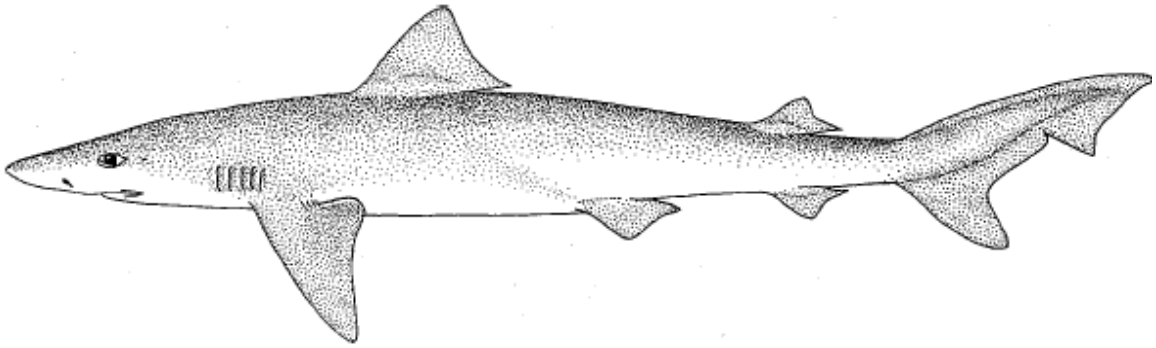
COSEWIC
Assessment and Status Report

on the

tope
Galeorhinus galeus

in Canada



SPECIAL CONCERN
2007

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Production note:

COSEWIC would like to acknowledge Scott Wallace, Gordon McFarlane and Jacquelynne King for writing the status report on the tope, *Galeorhinus galeus*, in Canada, prepared under contract with Environment Canada. The report was overseen and edited by Paul Bentzen, Co-chair, COSEWIC Marine Fishes Species Specialist Subcommittee, and Mart Gross, member, Marine Fishes Species Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le milandre *(Galeorhinus galeus)* au Canada.

Cover illustration:
Tope — Biological illustration of the tope. Source: Compagno 1984.

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COSEWIC
Assessment Summary

Assessment Summary – April 2007

Common name
Tope

Scientific name
Galeorhinus galeus

Status
Special Concern

Reason for designation
This Pacific coast shark is thought to be highly migratory across its range from Hecate Strait, BC to the Gulf of California. Tope shows no evidence of distinct populations and thus for the purposes of this assessment is considered a single population. It feeds primarily on fish, and in Canada occupies continental shelf waters between western Vancouver Island and Hecate Strait. Maximum length is less than two metres, maximum age is at least 45 years, maturity between 12 and 17 years, and generation time 23 years. Tope is noted for its high concentration of liver vitamin A, exceeding that of any other north-east Pacific fish species. Demand for vitamin A during World War II led to a large fishery that quickly collapsed due to over-exploitation. More than 800,000 individuals, primarily large adults, were killed for their livers between 1937 and 1949 throughout its migratory range. Tope is rarely seen today in Canadian waters. There is no targeted commercial fishery in Canada, but it continues to be caught as fishery bycatch in Canada and the U.S., and remains the target of small commercial and recreational fisheries in the U.S. Because there is no population estimate for tope, the sustainability of current catches cannot be assessed. The ongoing fishery mortality, the lack of a management plan for Canadian bycatch, and the long generation time and low fecundity of tope suggest cause for concern.

Occurrence
Pacific Ocean

Status history
Designated Special Concern in April 2007. Assessment based on a new status report.

COSEWIC
Executive Summary

tope
Galeorhinus galeus

Species information

Tope (*Galeorhinus galeus*), commonly referred to as soupfin shark, is one of 39 species belonging to the family Triakidae or houndsharks. Tope is the only representative from the family Triakidae on Canada's Pacific coast. In French this species is referred to as *milandre*.

The population structure of tope in Canadian waters and throughout the eastern Pacific is unknown. Tope are considered highly migratory, moving north during the summer and south into deeper waters during the winter. Assuming that tope found in Canada are part of a larger highly migratory population, genetic structure, if it exists would be restricted to behavioural mechanisms as there are no known geographical or ecological barriers to gene flow. For the purposes of this document, tope in Canada's Pacific waters are considered as a single designatable unit.

Distribution

Tope occur in temperate and subtropical seas between 68°N - 55°S latitude. Tope are found in the eastern Pacific from northern British Columbia (no records from Alaska) to the Gulf of California as well as waters off Peru and Chile. In Canada's Pacific waters records for tope occur primarily from continental shelf waters along Vancouver Island, Queen Charlotte Sound, and into Hecate Strait. There is no known research or commercial fishing record of tope being taken from the Strait of Georgia.

Habitat

Tope prefer temperate continental shelf waters from close inshore, including shallow bays, to offshore waters up to 471 m deep. They are generally thought to occur near the bottom but have been captured by pelagic floating longlines in deep waters. Pups and juveniles utilize shallow nearshore habitats for one to two years before moving offshore. There is no direct protection of tope habitat.

Biology

Little is known about the breeding behaviour of tope. The reproductive cycle for tope is reported as one to three years with a gestation period of one year. Tope are ovoviviparous, with females carrying between 6 and 52 pups released between March and July with pups being an average 35-37 cm long. Tope exhibit rapid growth during the first three years followed by steady growth until about 10 years of age and then slow continued growth through maturity. In the northeast Pacific maximum length of females is 195 cm and 175 cm for males. Aging and determination of longevity is constrained due to the difficulty in reading vertebral sections. Tope are slow growing and reach a maximum age of at least 45 years. Age of maturity in females is about 13-15 years and males at about 12-17 years. In eastern Pacific waters, females are mature at 150 cm total length and males are mature at 135 cm. Generation time is estimated at 23 years.

Movement patterns of tope in the northeast Pacific are poorly understood. Overall there appear to be both bathymetric and latitudinal movements that vary by both sex and season. Tagging studies suggest that at least some component of the population undergoes extended migrations and that they are capable of travelling long distances over a short period of time.

Commercial fisheries

Tope were the target of a brief but extensive commercial fishery throughout their northeast Pacific range beginning in 1937 in California and then in British Columbia, Oregon, and Washington in the early 1940s. The focus of the west coast tope fishery was for their liver which contains the highest concentrations of vitamin A of any fish on the Pacific coast. A total of approximately 840,000 tope may have been taken from the northeast Pacific population of which about 50,000 were landed in Canadian ports and an unknown amount actually caught in Canadian waters.

There are no present-day directed tope fisheries in Canada's Pacific waters. Tope are caught in low numbers as bycatch in trawl and longline fisheries while in pursuit for other commercial species. An estimated 143 tope per year are caught by the trawl and longline fleets.

Population sizes and trends

There are no indices of tope abundance anywhere in their northeastern Pacific range. Overall abundance and population trends in Canada's Pacific waters are unknown.

Limiting factors and threats

The intensive fishery for tope between 1937 and 1949 throughout their migratory range in the northeast Pacific would have caused a rapid depletion in the adult biomass. Since that time tope have not received any commercial or research attention aside from

reported landings by state fisheries departments and incidental catch in Canadian fisheries. A clear limitation to understanding the status of this species is the lack of information.

Special significance of the species

The liver of tope has the highest known concentration of vitamin A of any fish species on Canada's Pacific coast.

Existing protection

The IUCN lists tope as vulnerable (VU A1bd) globally based on its history of stock collapse in the northeast Pacific as well as from a reduction in the global population over the last 60 -75 years.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

tope

Galeorhinus galeus

in Canada

2007

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SPECIES INFORMATION

Name and classification

The tope (*Galeorhinus galeus*) is one of 39 species belonging to the family Triakidae or houndsharks. In Canada, tope is more commonly referred to as soupfin shark but is recognized by the American Fisheries Society as tope (Nelson *et al*. 2004). The genus *Galeorhinus* is derived from the Greek words "galeos" meaning a shark and "rhinos" which means nose. The tope is the only representative from the family Triakidae on Canada's Pacific coast. The tope has many common names. Countries in the southern hemisphere, in particular, Australia, New Zealand, and South Africa refer to tope as 'school shark'. Other common names include eastern school shark, flake, greyboy, greyshark, Penny's dog, schnapper shark, sharpie shark, Sweet William shark, tope oil shark, tope school shark, tope soupfin shark, and vitamin shark (http://www.flmnh.ufl.edu/fish/Gallery/Descript/TopeShark/TopeShark.html). In French this species is referred to as *milandre*.

Morphological description

The tope is a dark bluish grey in colour on its dorsal side which shades to white on the underside (Mecklenburg *et al*. 2002). They are reported to grow up to 195 cm in length. They have two dorsal fins, with the first dorsal fin well ahead of the pelvic fins and the second dorsal fin being about the same size as the anal fin (Figure 1). The caudal fin has a large subterminal lobe which is nearly as long as the lower lobe (Ebert 2003). Their snout is long and pointed and they have a large mouth. The eyes of tope are horizontally oval with conspicuous spiracles behind each eye.

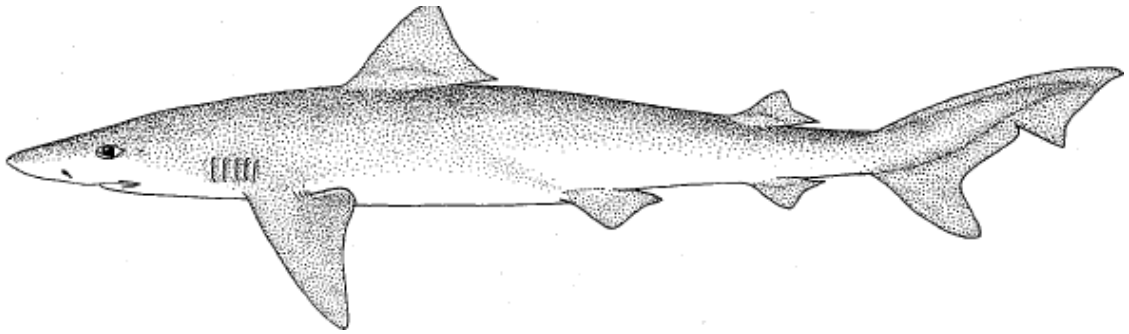

Figure 1. Biological illustration of the tope. Source: Compagno 1984.

Genetic description

The population structure of tope in Canadian waters and throughout the eastern Pacific is unknown. Conventional tagging studies in the 1940s reported two tope tagged off the California coast recaptured off Vancouver Island 3 and 26 months later (Herald and Ripley 1951). Tope are considered highly migratory, moving north during the summer and south into deeper waters during the winter (Ebert 2003). Assuming that

tope found in Canada are part of a larger highly migratory population, genetic structure, if it exists would be restricted to behavioural mechanisms as there are no known geographical or ecological barriers to gene flow. Tope in Australia showed a high degree of mitochondrial DNA similarity throughout their range; however, there was evidence of significant differentiation between South Africa and western Tasmania, Australia and weak evidence of restricted gene flow between eastern New Zealand and Australia (Ward and Gardner 1997).

Designatable units

For the purposes of this document, tope in Canada's Pacific waters are considered as a single designatable unit.

DISTRIBUTION

Global range

Tope occur in temperate and subtropical seas between 68°N - 55°S latitude. Tope are found in the eastern Pacific from northern British Columbia (no records from Alaska) to the Gulf of California as well as waters off Peru and Chile. Tope are distributed in the southwestern Pacific Ocean in waters off Australia and New Zealand. In the western Atlantic Ocean, its range is limited from southern Brazil to Argentina while in the eastern Atlantic it can be found from Iceland to South Africa, including the Mediterranean Sea. In the western Indian Ocean region, tope can be found in waters off South Africa (Compagno 1984).

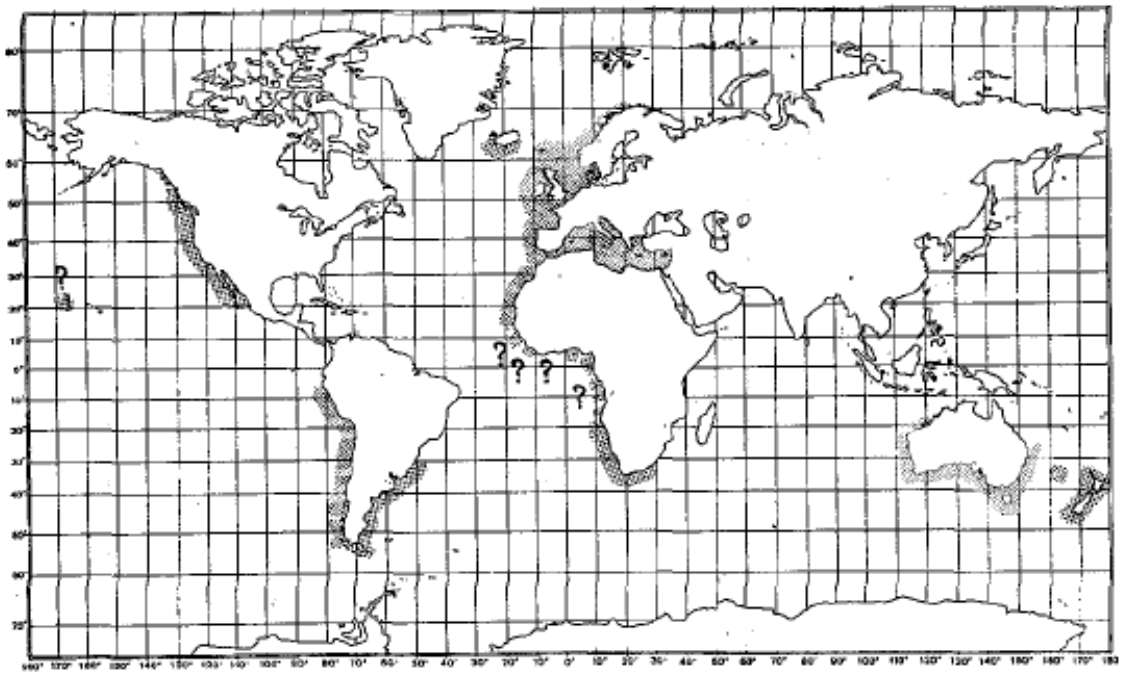

Figure 2. Global distribution of tope (shaded areas). Source: Compagno 1984.

Canadian range

In Canada's Pacific waters records for tope occur primarily from continental shelf waters along Vancouver Island, Queen Charlotte Sound, and into Hecate Strait. There are no known research or commercial fishing records of tope being taken from the Strait of Georgia (Figure 3). Based on commercial trawl records between 1996 and 2005, 95% of the records (N=109 sets with tope) fall between the depths of 47-285 m (Figure 4). The area between these two depths is ~73 600 km^2 which is considered to be the extent of occurrence in Canadian waters (Figure 5). Actual documented occurrences in Canada's Pacific waters based on 5X5 km grid squares sum to ~2000 km^2 which is used as a minimum area of occupancy estimate.

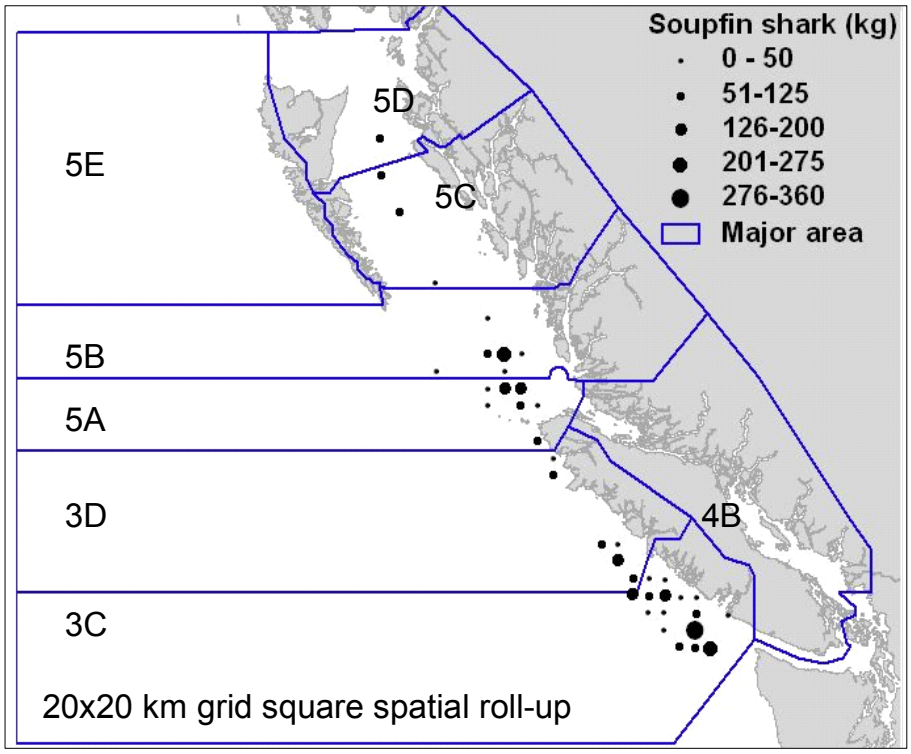

Figure 3. Canadian range of tope based on observations in the commercial hook and line and trawl fisheries between 1996 and 2005. Source: PacHarv database.

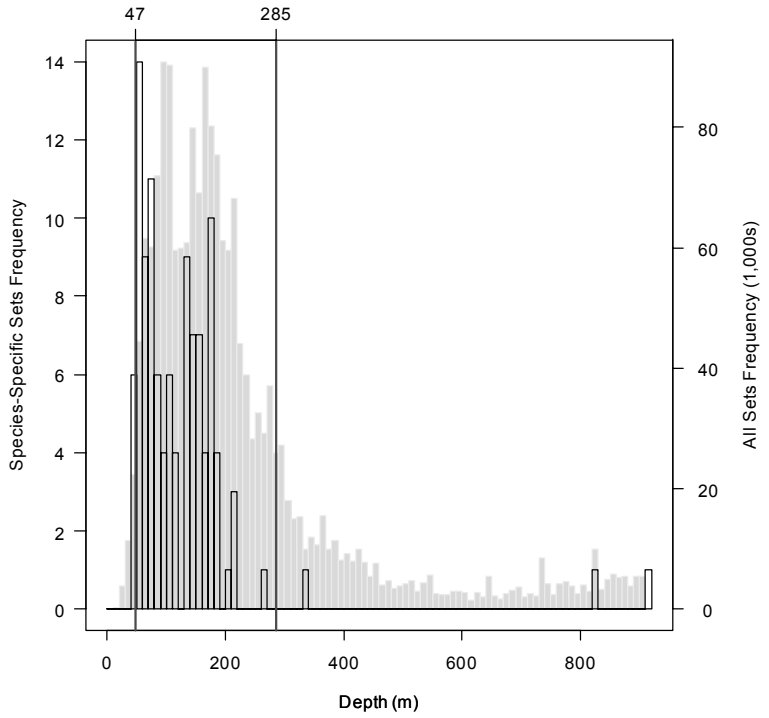

Figure 4. Depth distribution of commercial trawl tows coastwide between 1996 and 2005 with records of tope (clear bars) compared with the total trawl effort by depth (solid grey bars). Records between the vertical lines represent the depth interval accounting for 95% of the sightings. Source: PacHarvTrawl database.

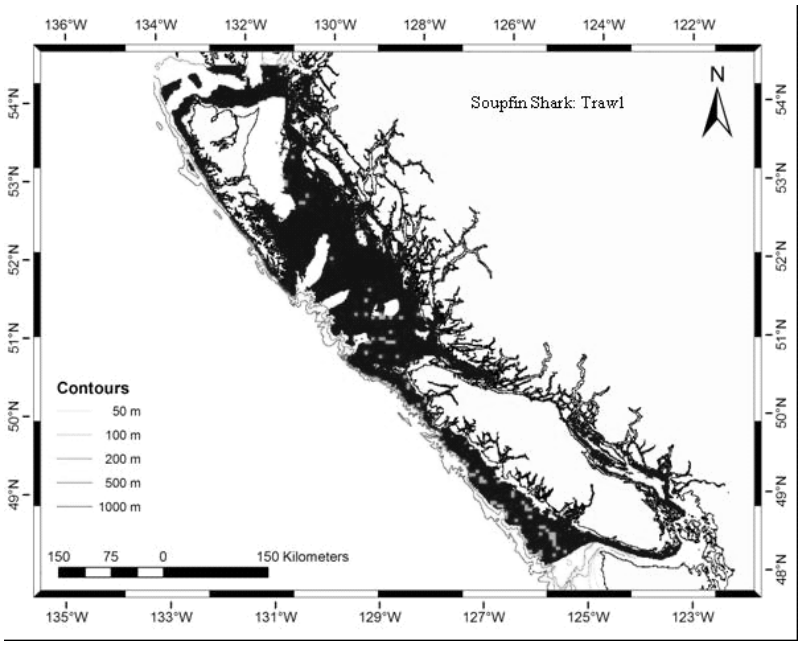

Figure 5. Possible distribution of tope in Canada's Pacific waters based on captures in the commercial trawl fishery between 1996 and October 2005. Grey areas represent locations with reported capture of tope based on a 5X5 km grid square. Black area represents depths between 47 and 285 m, the interval accounting for 95% of tope trawl catch. There are no records from the Strait of Georgia. Source: PacHarvTrawl database.

HABITAT

Habitat requirements

Compagno (1984) describes the habitat of tope as coastal pelagic, often well offshore but not oceanic. Ebert (2003) describes their habitat as temperate continental shelf waters from close inshore, including shallow bays, to offshore waters up to 471 m deep often near the bottom. They have been found in the surfline, bays, and submarine canyons. They are generally thought to occur near the bottom but have been captured by pelagic floating longlines in deep waters (Compagno 1984). Pups and juveniles utilize shallow nearshore habitats for one to two years before moving offshore.

Habitat trends

It is not known whether suitable habitat for tope has decreased or become less available.

Habitat protection/ownership

There is no direct protection of tope habitat. Some *de facto* protection may exist from a seasonal trawl closure on Dogfish Bank in Hecate Strait which is closed to bottom trawling from June 1 to July 15 to protect moulting Dungeness crabs (DFO 2005). Historically, much of the effort directed towards tope fishing occurred in this area during the months of June, July and August (Figure 6) (Barraclough 1948).

BIOLOGY

Current knowledge surrounding life history parameters of Pacific elasmobranchs has been summarized in an online life history matrix assembled by the Pacific Shark Research Centre at Moss Landing Marine Laboratories (http://psrc.mlml.calstate.edu/lht.php). The matrix includes up-to-date information on taxonomy, geographic range, age and growth, longevity, reproduction, demography, trophic interactions, habitat utilization, genetics, recruitment, mortality, and behaviour of 102 species. This matrix was drawn upon as an authoritative summary of the current state of tope knowledge in the northeast Pacific.

There has been no research on tope in Canadian waters. Information from U.S. waters is limited to research undertaken following the extensive fisheries during the late 1930s and early 1940s (Ripley 1946). The most recent and comprehensive biological information on tope is from populations around Australia and New Zealand that are targeted by commercial fisheries and to a lesser degree from populations from the northeast Atlantic. It should be noted that life history characteristics between ocean basins and/or hemispheres may not be comparable.

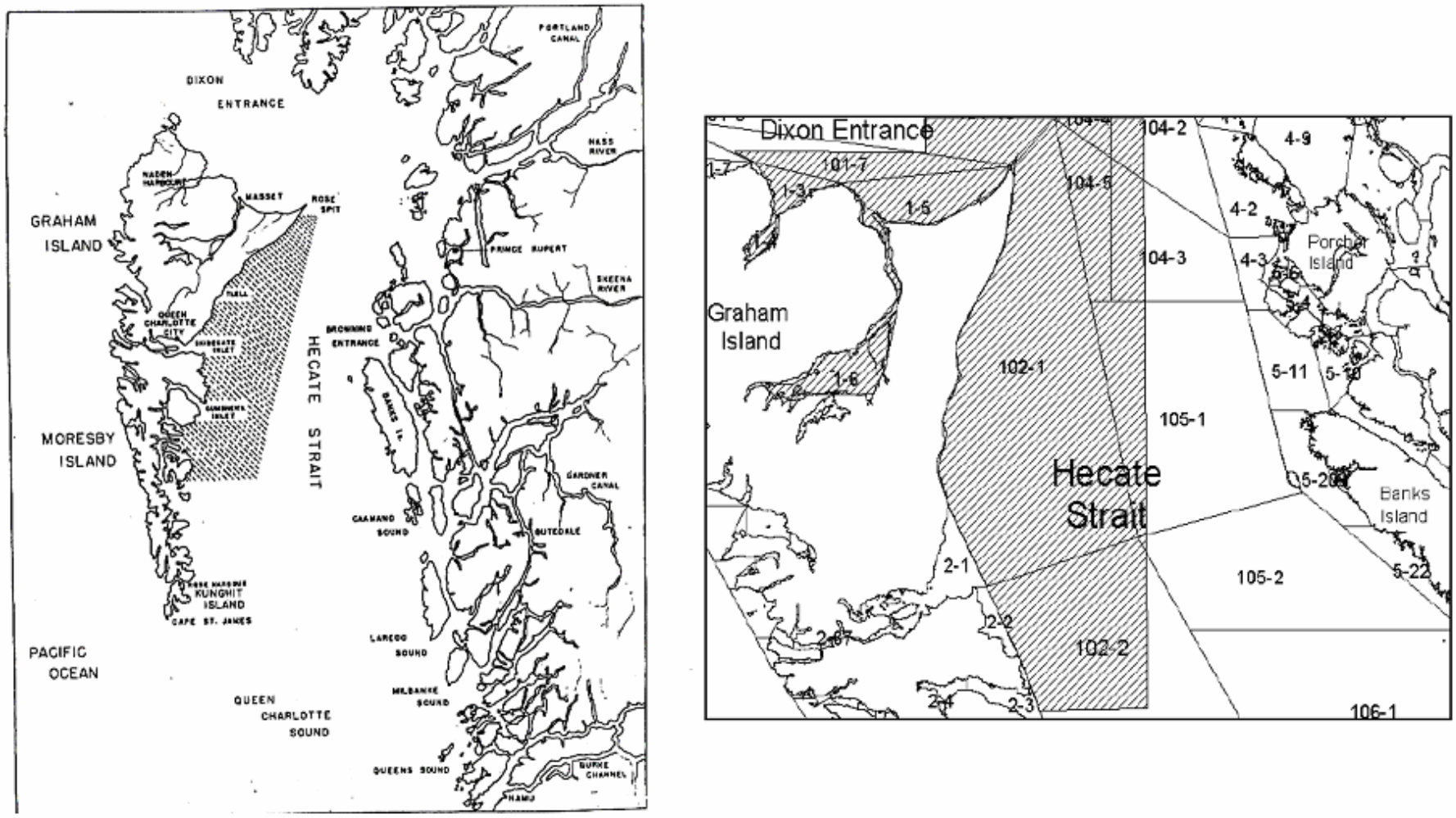

Figure 6. Historical fishing grounds for tope during the early 1940s (left panel); present-day soft-shell crab trawl closure (June-July) (right panel). Source: Barraclough 1948; DFO 2005.

Life cycle and reproduction

In the northeast Pacific, a single study indicating that few females have unfertilized eggs by May suggests that fertilization occurs primarily in the spring (Ripley 1946). Little is known about the breeding behaviour of tope. The reproductive cycle for tope is reported as one year in the eastern north Pacific (Ripley 1946), two years in Australia, (Olsen 1954) and up to three years off Brazil (Peres and Vooren 1991). Globally the gestation period is thought to be 12 months (Ripley 1946; Last and Stevens 1994). Tope are ovoviviparous, with females carrying between 6 and 52 pups near term depending on the size of the female (Ripley 1946; Compagno 1984; Ebert 2003). Parturition in the northeast Pacific is thought to occur between March and July with pups being an average 35-37 cm long (Ripley 1946).

Tope from Brazil, Australia, and New Zealand exhibit rapid growth during the first three years followed by steady growth until about 10 years of age and then slow continued growth through maturity (Peres and Vooren 1991; Moulton *et al*. 1992; and Francis and Mulligan 1998). In the northeast Pacific maximum length of females is 195 cm and 175 cm for males (Compagno 1984). Aging and longevity is constrained due to the difficulty in reading vertebral sections. The aging technique used in Brazil involving X-rays (Peres and Vooren 1991) is considered more reliable than the Australian technique using alizarin staining of the whole centrum (Moulton *et al*. 1992). Ferreira and Vooren (1991) found Brazilian tope to be slow growing and to reach a maximum age of 40 years, whereas Moulton *et al*. (1992) reported a faster growth rate and a maximum age of 20 years in Australia. Longevity in Australian tope; however, is estimated to be at least 45 years based on a tagged individual at liberty for 35 years (Moulton *et al*. 1989).

Age of maturity based on a study from New Zealand, found females to mature at about 13-15 years (and males at about 12-17 years) (Francis and Mulligan 1998). In eastern Pacific waters, females are mature at 150 cm total length and males are mature at 135 cm.

Generation time, which is the average age of parents of the current cohort, is estimated as the age at which 50% of the females are mature+ 1/M where M is the instantaneous rate of natural mortality. Instantaneous natural mortality of eastern Pacific tope has been estimated at 0.113 (Smith *et al*. 1998). Female tope are 50% mature at ~14 years of age (Francis and Mulligan 1998). Generation time is therefore 14+1/0.113=23 years.

Herbivory/predation

Tope are preyed upon by other elasmobranchs including the white shark (*Carcharadon carcharias*) and the broadnose seven gill shark (*Notorynchus cepedianus*) and possibly marine mammals (Ebert 2003). In New Zealand, the killer whale (*Orcinus orca*) has been reported taking tope off of commercial longlines (Visser 2000).

Dispersal/migration

Movement patterns of tope in the northeast Pacific are poorly understood. Inferences about movement are limited to patterns observed in the California commercial fisheries from 1941-1944 and from a small number of tope tagged. Overall there appear to be both bathymetric and latitudinal movements that vary by both sex and season (Ripley 1946). Off the northern California coast, Ripley (1946) found that 97.5% of the catch was composed of males (N=5724) whereas off the southern coast 97.8% of the catch were female (N=5020). In the middle the ratios were approximately equal. In southern California tope were most available to the fishery in the spring and summer whereas in northern California they were most abundant between October and December. When depth is considered, it was found that 98% (N=5025) of the females caught in southern California were caught in depths less than 37 m with 87% being caught in waters less than 18 m. In northern California, 97% of the males were caught in waters greater than 37 m, with 40% of the catch taken from waters over 90 m. Overall, female tope were present in southern California in shallow waters during spring and male tope were present in northern California in deep waters during fall.

There have been three tagging studies between southern California and Hecate Strait (N=427, 6 returns). One by the California Division of Fish and Game in 1943 (N=80, 1 return), another by volunteer fishers in California in 1949 (N=38, 3 returns), and finally a two year tagging study carried out by Oregon commercial fishers in 1948 (N=18, 0 returns) and 1949 (N=291, 2 returns) (summarized in Herald and Ripley 1951). Two recaptures of female sharks tagged in California were made ~1600 km away in Canadian waters in Hecate Strait and off the west coast of Vancouver Island after ~3 and 26 months at large respectively (Table 1). Four other recaptures were made between 121– 306 km from their tagging site. One male shark tagged off of Cape Scott, Vancouver Island was caught only two days later in Queen Charlotte Sound (~121 km). These limited results suggest that at least some component of the population undergoes extended migrations and that they are capable of travelling long distances over a short period of time.

In other jurisdictions, tagging studies have been far more extensive. In Australia from the 1940s to the 1990s, a total of 9638 sharks were tagged resulting in 1011 returns (Walker 1999). From 301 tag recaptures during the 1990s 65% of displacements were >500km for large females (>104cm TL), and 20 recaptures for the sexes combined had displacements >1000km with a mean distance between release and recapture positions of 415 km (Walker *et al*. 1997). The longest recorded displacement is 3016 km for a female (156cm TL at release) released in the Great Australia Bight and recaptured near the southeast coast of New Zealand's South Island after 1033 days. Similarly tagging studies in the northeast Atlantic have also demonstrated extensive movements. Sharks tagged off of England and Ireland were recaptured as far away as Iceland (2416 km), the Azores, and the Canary Islands.

Table 1. Summary of tope tag returns in the northeast Pacific. Source: Herald and Ripley (1951).

Date Tagged (m/d/y)	Sex	Study	Approximate tagging location	Recovery date (m/d/y)	Time/distance at large	Location of recovery
7/18/1943	F	CA Fish &Game	Ventura, CA	9/11/1945	26 months/ 1600 km N	Nootka Sound, BC
1/20/1949	M	CA fishers	Baja, CA	7/5/1949	5.5 months/ 160 km N	San Diego, CA
5/18/1949	F	CA fishers	Pt. Mugu, CA	8/29/1949	3.3 months/ 1760 km N	Hecate Strait, BC
5/23/1949	F	CA fishers	Malibu Pt., CA	5/27/1949	4 days/ 150 km S	Encinitas, CA
5/7/ 1949	M	Oregon fishers	Pt. Sur, CA	8/28/1949	2.7 months/ 144 km N	Halfmoon Bay, CA
8/5/1949	M	Oregon fishers	Cape Scott, BC	8/7/1949	2 days/ 120 km E	Queen Charlotte Sound, BC

Generalized movement patterns from both Australia and the northeast Atlantic suggest a seasonal bathymetric migration with the sharks moving into deeper water during the coldest months and returning inshore in spring to give birth (Walker 1999).

Interspecific interactions

Ripley (1946) provides the only documentation of tope diet in the northeast Pacific. This shark is an opportunistic predator feeding upon several fish species in both pelagic and demersal environments (Ebert 2003). Items include fish, Clupeidae (*Sardinops sagax*), Pleuronectiformes-flatfish, plainfin midshipman (*Porichthys notatus*), Scorpaenidae-rockfishes, Scombridae-mackerel, and Embiotocidae-perches, as well as cephalopods (Teuthoidea) (Ripley, 1946). A recent study in the northeast Atlantic found the diet of adult tope to exist almost entirely of fish (98.8% by weight) (Morato *et al*. 2003). In Australia teleosts comprised 47% of the diet by weight followed by cephalopods (37%) (Walker 1989). Diet likely varies considerably by season and size of the shark.

Adaptability

The widespread presence of tope throughout the world indicates this species is able to survive in several environments. Tope are likely able to adapt to natural fluctuations in the environment such as changes in prey type and availability. It is unknown how well tope is able to adapt to anthropogenic changes in the environment or drastic changes to population structure due to fishing mortality.

COMMERCIAL FISHERIES

Historical (1930-1949)

In the early 1930s, tope fisheries in the northeast Pacific were composed of a small fresh fillet market in California and a “substantial” dried fin Asian export market (Ripley 1946; Appendix 1). Prior to 1937 there was no distinction of species in the catch record and therefore the catch shown in Appendix 1 is for all species of shark. Beginning in 1937 tope became the target of a brief but extensive commercial fishery throughout their northeast Pacific range. The fishery began in California and then followed in British Columbia, Oregon, and Washington in the early 1940s (Figure 7). The focus of the west coast tope fishery was for their liver which contains the highest concentrations of vitamin A of any fish on the Pacific coast (Bailey 1952). Prior to World War II, Vitamin A was supplied to the U.S. market processed from Atlantic cod in European waters. The European trade route was greatly curtailed during war times resulting in the rapid development of U.S. based vitamin A sources including the lucrative tope. On average, tope livers contain 4.5 to 20 times more vitamin A per gram then spiny dogfish, the next most important shark that was concurrently being targeted (Bailey 1952).

By 1939, about 600 vessels were fishing for tope along the entire coast of California (Byers 1940). Prior to 1941 there was no distinction made between species in the California shark catch, and therefore for the purposes of this report the proportion (52.9%) of tope in the total catch after 1941 is applied to the total shark landings pre-1941 as reported in Ripley (1946). Ripley (1946) stated that the post-1941 California landings were minimums as much of the tope catch was still being recorded as unidentified shark. Furthermore, Ripley (1946) pointed out that the percentage of tope in the landings between 1939 and 1941 was undoubtedly higher than in years following 1941. The California landings presented in Figure 7 should therefore be considered minimum estimates. All shark landings from 1930 to the California fishery peaked in 1939 (2209 t) which was before the Canadian fishery for tope had even begun. By 1942 landings of tope in the California fishery had dropped by over 50% and by 1945 the fishery had collapsed. Over 10,000 t were taken over a seven year period which according to Ebert (2003) decimated the population particularly the nursery areas in San Francisco and Tomales Bays.

The Canadian fishery took place primarily off the west coast of Vancouver Island and in Hecate Strait (Figure 6). Fishing took place in about 45 m of water using a variety of fishing gear including halibut longlines, dogfish longlines, trawls, sunken gillnets and driftnets (Barraclough 1948). Sunken gillnets proved to be the most effective technique in Canada although longlines were also commonly used. Preferred longline technique involved using hooks baited with herring, suspended about 2 m from the bottom (Clemens and Wilby 1946).

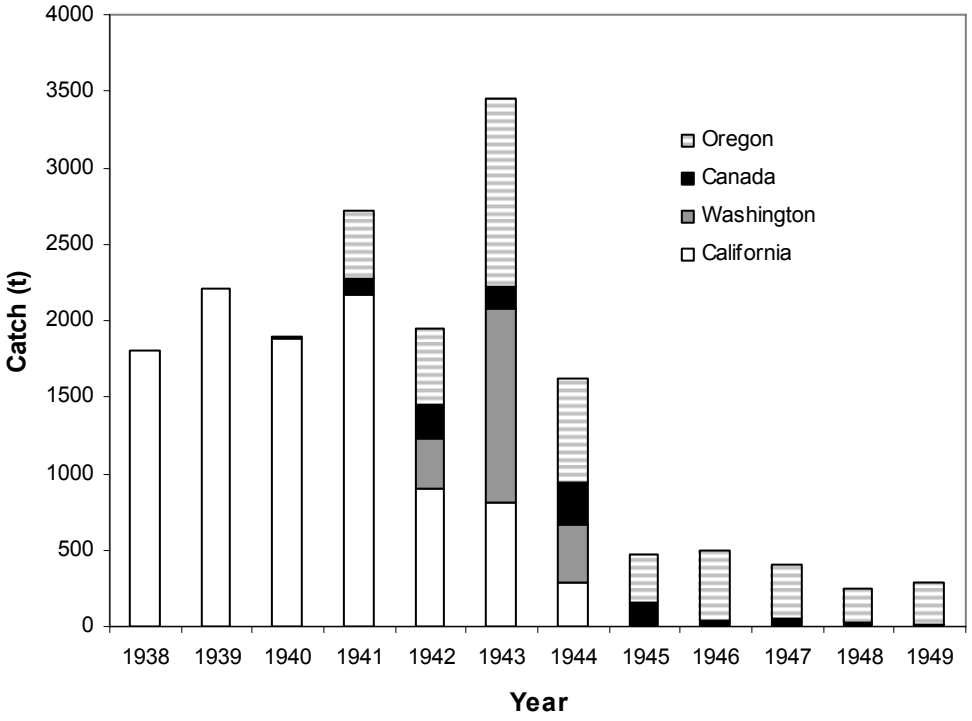

Figure 7. Estimated catch of tope along the west coast of North America from 1938 to 1949. Data sources: California-Ripley (1946), Canada-Barraclough (1946) and Bailey (1952), Oregon (Westrheim 1950), Washington (Department of the Interior Information Service). California landings pre-1941 based on proportion (52.9%) of total shark landings. Canadian, Washington, and Oregon liver landings converted to whole weights based on conversion from Bailey (1952). See Appendix 1 for values.

In the early catch statistics only the weight of the liver was reported. The liver comprises approximately 10% of the weight of adult male tope (Bailey 1952). The fishery started off quite small in 1940 with reported liver landings of 1.2 t or approximately 12 t of round fish (Figure 7). By 1942, British Columbia newspapers reported the value of tope livers at between $11-12.80/kg which was approximately 25 times the value of spiny dogfish livers. In 2006 dollars the value is equivalent to $139-161/kg. By 1944, prices had climbed higher to $20.40/kg (Anon. 1944a). A 1944 fishing article reported that a boat fishing off the west coast of Vancouver Island caught 700 sharks in 17 days producing 2941 kg of liver valued at $20,000 ($_{2006}$Present value $215 000) (Anon. 1944b). The high value fuelled by rising use of vitamin A and cut-off of foreign supplies initiated an all-out bonanza on tope. The British Columbia fishery peaked in 1944 at 278 t or approximately 13,200 individuals.

Note: The total number of individuals is estimated by using the average length of tope in the catch off California (160 cm) (Ripley 1946) and the length-weight relationship $Wt_{kg}=2.17x\ 10^{-6}\ (TL)^{3.17}$(Olsen 1954) for an average weight per individual of 21 kg.

By 1944 landings of tope off California had declined by 65% from the 1943 total despite intensified efforts (Anon. 1944a). Canadian fishing magazines were reporting a decrease in Canadian abundance starting in 1944 and by 1946 the Canadian fishery had substantially diminished. In 1947 vitamin A was first synthesized, which removed the demand on natural sources for its procurement. By 1949 the Canadian fishery for tope had ended.

Tope fishing was also carried out by fishers out of Washington and Oregon States along the west coast of the U.S. but also a lot of effort in Canadian waters (Westrheim 1950). Some of the American vessel landings were recorded in Canadian landings due to special circumstances permitted by the *War Measures Act* (Anon. 1942), but most American vessels landed their livers in U.S. ports. Washington state landings from 1942, 1943, and 1944 are published in U.S. Department of the Interior Information Service press releases available online (http://news.fws.gov/historic/1944/19440410.pdf). These records represent the minimum landings of livers in Washington as they only represent three years (Figure 7).

Tope livers landed in Oregon State from 1941 to 1949 are summarized in Westrheim (1950). Landings in Oregon peaked in 1943 with liver landings of 122 t or ~1200 t round weight (Figure 7). It is interesting to note that the Oregon fleet used primarily floating gillnets on average 1.9 km long which apparently was more effective during summer months and were used up to 160 km from shore (Westrheim 1950). The fleet progressed northwards with most of the fleet fishing off of California in April-June and then off of Washington State and British Columbia in August through October.

Based on an approximate weight of 21 kg/shark, a total of approximately 840,000 tope may have been taken from the northeast Pacific population of which about 50,000 were landed in Canadian ports and an unknown amount actually caught in Canadian waters (Appendix 1).

Present-day fishery interactions in U.S. waters

Present-day commercial catches of tope in U.S. waters have been reported since 1976. Catches between 1976 and 1994 have varied between 100–380t whole weight (Walker 1999). In California, landings from 1995 to 1999 varied between 20 and 45 t dressed weight (Ebert 2001) or 30-68 t whole weight based on a conversion factor of 1.5 (Walker 1999). From 2001 to 2004 annual average landings in California waters averaged 21 t (CDFG 2001; 2002; 2003; 2004).

Recreational catches of tope primarily in waters off California are “sketchy at best” and are underreported (Ebert 2001). Tope are still sought for their meat.

Present-day fishery interactions in Canadian waters

There are no directed shark fisheries in Canada’s Pacific waters with the exception of spiny dogfish. Tope are caught in low numbers as bycatch in trawl and longline

fisheries while in pursuit of other commercial species. Since 1997 the commercial groundfish trawl fleet has been monitored with 100% at-sea observer coverage. Prior to 2001, reporting of non-commercial elasmobranch species was incomplete in this fishery (McFarlane pers. comm. 2006). Between 2001 and 2005 an average of 651 kg/yr of tope was observed caught by British Columbia trawl fisheries (Figure 8). Assuming an average weight of ~21 kg, a total of 31 tope a year may be caught by the trawl fleet. Most of the catch is from Pacific Marine Fisheries Commission (PMFC) areas 3C/D (Table 2; Figure 3). Tope have been captured in all months of the year with the exceptions of March and April (Appendix 2a,b).

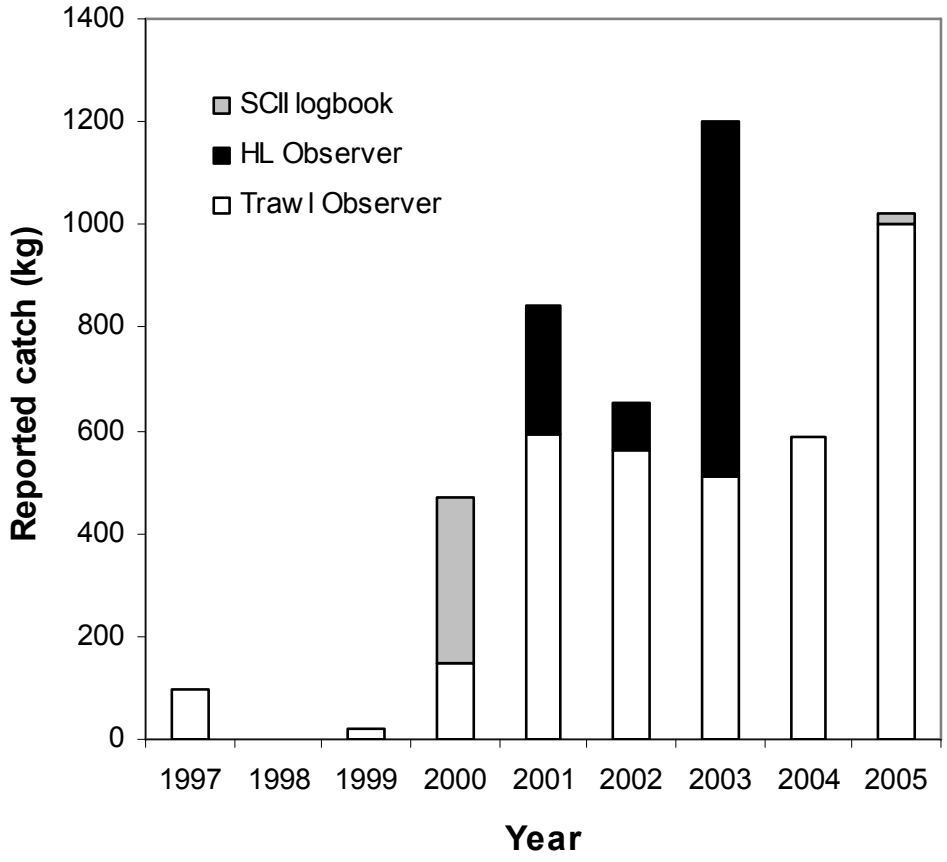

Figure 8. Reported commercial catch (t) of tope in Canada's Pacific waters by year. Note that hook and line observer coverage represents only 10-15% of the total number of trips. Source: PacHarv database.

Table 2. Commercial trawl catch (kg) of tope by year and PMFC area in Canada's Pacific waters based on at-sea observer coverage from 1996 to 2005. Data prior to 2001 is considered incomplete and not included in average. Estimated number of sharks based on a mean weight of 21 kg. Source: PacHarvTrawl database.

	Area and Catch (kg)-Trawl							
Year	3C	3D	5A	5B	5C	5D	Total	Est. # sharks
1997	27	24	45				96	5
1999					18		18	1
2000	94		36		18		148	7
2001	273	82	58	68	29	83	592	28
2002	75	116	263	45	36	27	562	27
2003	200	14	109	101	86		509	24
2004	265	254	68				587	28
2005	538	147	56	191	73		1004	48
Total (kg) (1997-2005)	**1472**	**637**	**635**	**405**	**260**	**110**	**3516**	**168**
Average (kg) (2001-2004)	**270**	**123**	**111**	**101**	**56**	**55**	**651**	**31**

Beginning in 2000, hook and line fisheries (i.e., halibut, rockfish, lingcod, and spiny dogfish) also started to receive limited observer coverage of between 10-15%. Between 2001 and 2004 an average of 259 kg/yr of tope was observed captured by hook and line fleets (Figure 8; Table 3). An additional amount of 343 kg has been reported in fisher logbooks (Table 3). Because hook and line fleets only receive partial observer coverage (i.e., ~10-15%) the actual catch is larger but presently unknown. As of April 2006 all hook and line licensed vessels operating in Canada's Pacific waters will be subject to 100% at-sea observer coverage in the form of electronic monitoring. A more accurate understanding of tope catch will be possible with the use of this technology. The mortality rate of the discarded sharks is unknown. Overall, the preliminary observer data indicates that the bycatch of tope in Canadian waters is likely minimal. If the annual observed catch by the hook and line represents ~15% of the actual catch, then perhaps 2 t/yr may be caught by this type of gear with an additional 1 t/yr caught by the trawl fleet for a combined maximum of 3t/yr or ~143 individual tope. The impact of this catch on the population depends on the size of the population which at present time is completely unknown (see *Population Sizes and Trends* section).

Table 3. Reported catch (kg) of tope in Canada's Pacific waters by hook and line fleets from observer and logbook programs. Estimated number of sharks based on a mean weight of 21 kg. Source: PacHarvHL database.

Year	HL Observed catch (kg)	HL Logbook catch (kg)	Est. # of sharks
2000		323	15
2001	250		12
2002	92		4
2003	693		33
2004	0		
2005		20	1
Total (kg)	**1035**	**343**	**66**
Average (kg)	**259**		

POPULATION SIZES AND TRENDS

Search effort

Tope was first recorded from British Columbia waters in 1891 by Ashdown Green who reported it to be rather common along the coast (Clemens and Wilby 1946). At present time there are no indices available to assess tope population trends anywhere in their northeast Pacific range. The National Marine Fisheries Service triennial bottom trawl survey (1977-2001) has only 23 tope captures between California and waters off southern Vancouver Island over eight survey years. Only two records are from tows north of 48º (NMFS Triennial survey, unpublished data). The International Pacific Halibut Commission annual set line survey has 45 records of tope dating back to 1996 but they are not caught regularly enough to develop an index of abundance (Appendix 3). There have been no tope captured by Canadian research surveys (GFBio database).

Abundance and trends

There are no indices of tope abundance anywhere in their northeastern Pacific range. The only research published on tope in British Columbia is from Barraclough's (1948) account of the fishery and a brief mention by Westrheim (1950). Barraclough estimated that 40% of all tope livers landed in British Columbia were landed by sunken gillnet boats fishing primarily for spiny dogfish from May to October in northwestern Hecate Strait (see Figure 6). We examined catch and effort of present-day fishing in this area between 1996 and October 2005 and found no records of tope catch over the same months despite 7243 hours of trawling effort and 1632 sets made with hook and line gear (Figure 9). It should be noted that the gear types presently being used are quite different than the preferred historical gear type involving sunken gillnets.

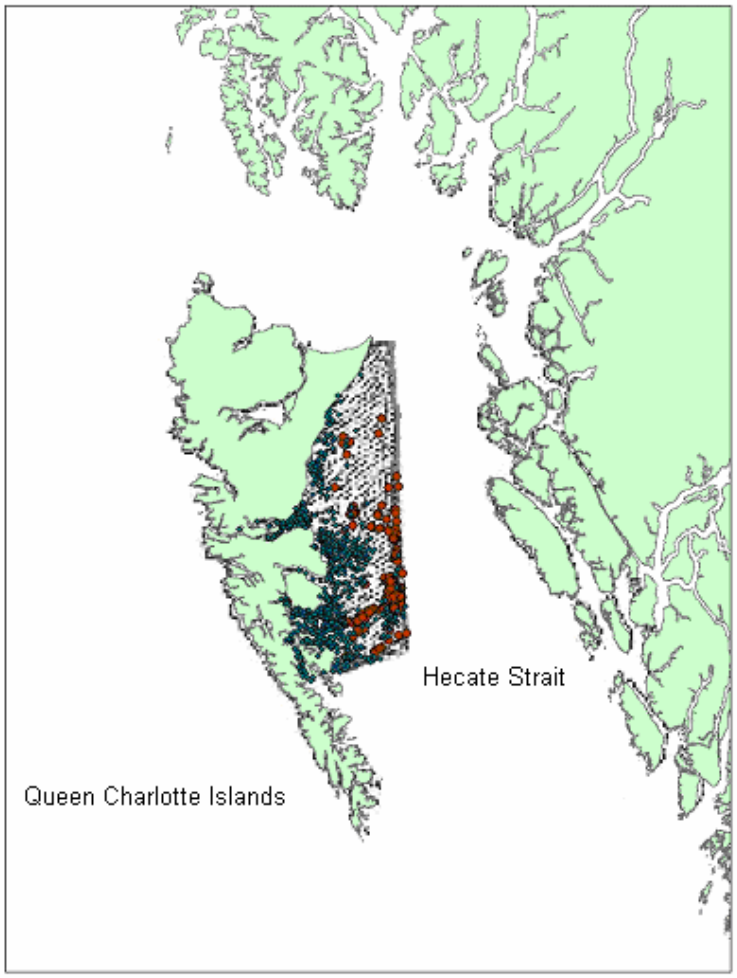

Figure 9. Overlay of fishing effort by trawl vessels (red circles) and hook and line vessels (grey circles) fishing between 1996 and October 2005 on historical tope fishing grounds. Source: PacHarvHL and Trawl databases.

The absence of present-day tope catch records from this region is difficult to interpret. On one hand there is considerable present-day fishing effort and therefore one would expect that if present, the sharks would be occasionally captured by either commercial or recreational fisheries. Worldwide, tope are regularly captured by trawl gear as bycatch and in some areas are actually targeted by this gear type so it would be expected that if present in northwest Hecate Strait they would appear in observer catch records (Walker 1999). Likewise, bottom-set longlining is another common technique for capturing tope in many places in the world and was also used in British Columbia during the historic directed fishery. Based on the fishing effort it appears that tope have not been present in this area in recent years (1996-2005).

On the other hand, the world's foremost expert on tope fisheries reports that this species is not an easy quarry (Walker 1999). Fishers need considerable experience and

skill to successfully find and catch them because of their schooling and highly migratory characteristics. If fishers are not directly targeting tope they may simply not catch them. Longline effort, although quite extensive, is primarily targeting lingcod, spiny dogfish and rockfish which may not overlap with the preferred habitat of tope. Another factor is that only a small percentage of the hook and line fleet is monitored by at-sea observers and therefore the actual present day catch of tope in this region is not fully reported. Finally, Hecate Strait represents the northern extent of tope distribution and therefore environmental conditions may play a role in their inter-annual distribution. It is possible that the abundance of tope in Hecate Strait during the 1940s was due to suitable environmental conditions.

In conclusion, the absence of present day catch records in an area of known historical abundance is of interest but there is presently insufficient information to fully explain this observation. Overall abundance and population trends in Canada's Pacific waters are unknown.

Rescue effect

British Columbia represents the northward extension of tope range in the northeast Pacific. Rescue effect from southerly waters is likely possible but is presently unknown. The extent of a rescue effect depends on both the rate of interchange between U.S. and Canadian waters as well as the current abundance. Populations in U.S. waters have not been studied in over 50 years (Ebert 2001). Based on a very limited tagging study in the 1940s there is indication that some portion of the otherwise more southerly centred population migrates and utilizes Canadian waters. It is suspected that tope are primarily seasonal visitors to Canadian waters; however, trawl observer data indicates that they can be caught year round except for March and April (Appendix 2). In other areas of the world, tope are known to make large latitudinal seasonal migrations (see review by Walker 1999) suggesting the same may occur in the northeast Pacific. Overall, it is reasonable to assume that if populations in U.S. waters are healthy they are potentially abundant in Canadian waters providing the environmental conditions are suitable. Similarly, if the tope population in U.S. waters is depleted it would be expected that abundance in Canadian waters would also be diminished.

LIMITING FACTORS AND THREATS

The intensive fishery for tope between 1937 and 1949 throughout their migratory range in the northeast Pacific would have caused a rapid depletion in the adult biomass resulting in the collapse of the fishery (Walker 1999; Ebert 2003). Since that time tope have not received any commercial or research attention aside from reported landings by state fisheries departments and incidental catch in Canadian fisheries. An ongoing, unreported recreational fishery occurs off California (Ebert 2001). A clear limitation to understanding the status of this species is the lack of information.

The degree to which the stock has recovered or remained depressed since the 1940s is unknown. Walker (1999) argues that although the fishery collapsed during the 1940s, it is unlikely the stock collapsed. He argues that sharks targeted during this brief period were mainly of a relatively large size and because the small juveniles, which would take several years to recruit to the fishery, were only lightly fished it is likely the stocks should have recovered after fishing ceased. However, it is unknown whether unreported recreational fishing and small amounts of commercial fishing since the 1950s have impeded recovery. Since the 1940s there has not been any major incentive to target tope in the northeast Pacific. Other sharks such as the thresher shark (*Alopias vulpinus*) and shortfin mako (*Isurus oxyrinchus*) are more valuable in the marketplace and easier to capture than tope (Walker 1999). Canadian catch and mortality is unknown but likely less than 3t/yr. U.S. catch is presently approximately 21 t/yr for a combined estimated northeast Pacific removal of 24 t/yr.

In the seven years between 1938 and 1944 approximately 15,600 t of tope may have been removed from waters along the west coast of North America. This catch can be used as a surrogate for a minimum historic population. Present-day population biomass and recovery level are unknown.

SPECIAL SIGNIFICANCE OF THE SPECIES

The ecological role of tope is not well understood. Tope occupy a high trophic level and readily prey upon almost any pelagic and demersal fish suggesting they are important species structuring marine food webs (Ebert 2003). The meat is of excellent quality and their fins can be used to make high quality soup stock. The liver of tope has the highest known concentration of vitamin A of any fish species on Canada's Pacific coast (Bailey 1952).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The IUCN lists tope as vulnerable (VU A1bd) globally based on its history of stock collapse in the northeast Pacific as well as from a reduction in the global population over the last 60 -75 years (Stevens 2000). In Canada's Pacific waters, no sharks, with the exception of spiny dogfish, can be retained, thereby removing any incentive to catch any shark species including tope. Tope caught by trawl can be landed; however, this gear type has caught very few in Canadian waters.

TECHNICAL SUMMARY

Galeorhinus galeus
Tope Milandre
Range of Occurrence in Canada: Pacific Ocean

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **Based on spatial extent of the depth interval representing 95% of the captures in the trawl fishery.**	73 600 km²
• *Specify trend in EO*	Unknown
• *Are there extreme fluctuations in EO?*	Unknown
• *Area of occupancy (AO) (km²)* **Based on occurrence in the commercial trawl fishery represented in 5X5 km grid squares. This value is a minimum.**	2000 km² (minimum)
• *Specify trend in AO*	Unknown
• *Are there extreme fluctuations in AO?*	Unknown
• *Number of known or inferred current locations*	Unknown
• *Specify trend in #*	Unknown
• *Are there extreme fluctuations in number of locations?*	Unknown
• *Specify trend in area, extent or quality of habitat*	Unknown, likely stable
Population Information	
• *Generation time (average age of parents in the population)*	23 years
• *Number of mature individuals*	Unknown
• *Total population trend:*	Unknown
• *% decline over the last/next 10 years or 3 generations.*	Unknown
• *Are there extreme fluctuations in number of mature individuals?*	Unknown, not likely
• *Is the total population severely fragmented?*	Not likely
• *Specify trend in number of populations*	Unknown
• *Are there extreme fluctuations in number of populations?*	Unknown, not likely
• List populations with number of mature individuals in each: unknown	
Threats (actual or imminent threats to populations or habitats)	
On a global level fishing is the single largest threat to populations. Historical overfishing in the northeast Pacific during the late 1930s and early 1940s would have severely reduced the population. Fishing pressure on the NE Pacific population has been very low over the last 60 years and at present time likely poses a minimal threat; however, the population size is unknown.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA: Status of tope in US waters south of the Canadian border is unknown. Tope have not been recorded from Alaskan waters.**	
• *Is immigration known or possible?*	Yes, highly migratory, likely only seasonal use of Canadian waters.
• *Would immigrants be adapted to survive in Canada?*	Yes, seasonally
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	Likely, but unknown.
Quantitative Analysis [provide details on calculation, source(s) of data, models, etc]	A quantitative analysis was not undertaken.
Current Status COSEWIC: Special Concern (2007) IUCN: vulnerable (VU A1bd) globally	

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code**: n/a

Reasons for Designation:

This Pacific coast shark is thought to be highly migratory across its range from Hecate Strait, BC to the Gulf of California. It shows no evidence of distinct populations and thus for the purposes of this assessment is considered a single population. It feeds primarily on fish, and in Canada occupies continental shelf waters between western Vancouver Island and Hecate Strait. Maximum length is less than two metres, maximum age is at least 45 years, maturity between 12 and 17 years, and generation time 23 years. The species is noted for its high concentration of liver vitamin A, exceeding that of any other north-east Pacific fish. Demand for vitamin A during World War II led to a large fishery that quickly collapsed due to over-exploitation. More than 800,000 individuals, primarily large adults, were killed for their livers between 1937 and 1949 throughout its migratory range. This shark is rarely seen today in Canadian waters. There is no targeted commercial fishery in Canada, but it continues to be caught as fishery bycatch in Canada and the U.S., and remains the target of small commercial and recreational fisheries in the U.S. Because there is no population estimate, the sustainability of current catches cannot be assessed. The ongoing fishery mortality, the lack of a management plan for Canadian bycatch, and the long generation time and low fecundity suggest cause for concern.

Applicability of Criteria

Criterion A: (Declining Total Population): No information exists on population trends.

Criterion B: (Small Distribution, and Decline or Fluctuation): Does not apply because the extent of occurrence is believed to exceed 20,000 km^2 and the area of occupancy is likely greater than 2,000 km^2.

Criterion C: (Small Total Population Size and Decline): No information exists on population size, or trends.

Criterion D: (Very Small Population or Restricted Distribution): No information exists on population size; restricted distribution does not apply as area of occupancy is much greater than 20 km^2.

Criterion E: (Quantitative Analysis): Not undertaken.

ACKNOWLEDGEMENTS AND AUTHORITIES CONSULTED

The authors thank Vanessa Hodes at the Pacific Biological Station who assembled much of the data required for this report; Mark Wilkins at the National Marine Fisheries Service who provided the Triennial Survey data and Claude Dykstra at the International Pacific Halibut Commission for providing the setline survey data.

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Dr. Scott Wallace is an independent consultant based on Vancouver Island, BC. His interests are best management practices and the sustainability of Pacific fisheries. Dr. Gordon (Sandy) McFarlane is a DFO scientist at the Pacific Biological Station, BC where he studies the biology and distribution of sharks and skates. Dr. Jacquelynne King is a DFO scientist at the Pacific Biological Station, BC where she studies age and growth parameters for big and longnose skates, ageing methodology for sixgill sharks, and distribution and migration of spiny dogfish.

Appendix 1. Estimated catch (t) of tope along the west coast of North America. Data sources: California-Ripley (1946), Canada-Barraclough (1946) and Bailey (1952), Oregon (Westrheim 1950), Washington (Department of the Interior Information Service). California landings 1938-1940 are based on proportion (52.9%) of total shark landings found in Ripley (1946). Canadian, Washington, and Oregon liver landings converted to whole weights based on 10:1 conversion from Bailey (1952). Estimated number of sharks based on mean weight of 21 kg.

	California	Estimated catch (t) of tope					Est. # of sharks
Year	Total Sharks (t)	California	Washington	Oregon	Canada	Total	
1930	293						
1931	270						
1932	385						
1933	213						
1934	238						
1935	251						
1936	214						
1937	414						
1938	3400	1799				1799	85667
1939	4176	2209				2209	105190
1940	3557	1881			12	1893	90143
1941		2168		452	105	2725	129762
1942		903	330	498	221	1952	92952
1943		810	1271	1222	144	3447	164143
1944		286	379	679	278	1622	77238
1945				317	160	477	22714
1946				452	41	493	23476
1947				362	47	409	19476
1948				226	24	251	11905
1949				271	18	290	13762
Total (t)		**10056**	**1980**	**4479**	**1050**	**17565**	**836428**

Appendix 2a. Total catch (kg) of tope by month and PMFC area in Canada's Pacific waters based on at-sea observer coverage in commercial trawl fisheries from 1996 to 2005. Source: PacHarvTrawl database.

Area and Catch (kg)-Trawl							
Month	**3C**	**3D**	**5A**	**5B**	**5C**	**5D**	**Total**
January	376	365	254		32		1027
February	313	60	86				459
March			No records				0
April			No records				0
May	27	36					63
June	169	88		45	61	19	382
July	297	23	63	206	104	63	756
August	213			97	27	27	364
September	76		97	23	18		214
October		63	36	33	18		150
November			36				36
December			64				64
Total	**1471**	**635**	**636**	**404**	**260**	**109**	**3515**

Appendix 2b. Average catch (kg) of tope by month and PMFC area in Canada's Pacific waters based on at-sea observer coverage in commercial trawl fisheries from 1996 to 2005. Source: PacHarvTrawl database.

Area and Catch (kg)-Trawl							
Month	**3C**	**3D**	**5A**	**5B**	**5C**	**5D**	**Total**
January	38	37	25	0	3	0	103
February	31	6	9	0	0	0	46
March			No records				0
April			No records				0
May	3	4	0	0	0	0	7
June	17	9	0	5	6	2	39
July	30	2	6	21	10	6	75
August	21	0	0	10	3	3	37
September	8	0	10	2	2	0	22
October	0	6	4	3	2	0	15
November	0	0	4	0	0	0	4
December	0	0	6	0	0	0	6
Total	148	64	64	41	26	11	354

Appendix 3. Records of tope in Canada's Pacific waters (IPHC Survey Area 2B) from the International Pacific Halibut Commission setline survey. Source: IPHC setline database.

Year	Station	# Tope observed
1996	10228	1
1996	9117	2
1997	6034	1
1997	6029	1
1997	12117	1
1999	2134	2
1999	2040	1
2001	2014	1
2003	2067	4
2003	2070	1
2004	2048	1
2004	2075	1
2004	2069	1
2004	2068	1
2004	2010	6
2004	2015	1
2004	2016	8
2004	2019	3
2004	2024	1
2004	2035	1
2004	2065	1
2004	2081	1
2004	2001	2
2004	2145	1
2004	2136	1
Total		**45**